Remarks

Claims 1-21 were pending. Claims 1-9, 14-15, and 18 have been amended. As a result of this amendment, claims 1-21 remain pending. Reexamination and reconsideration are requested in light of the accompanying amendments and remarks.

The rejection of claims 1-21 under the judicially created doctrine of obvious-type double patenting as unpatentable over claims 1-23, and 28-33 of U.S. Patent No. 6,756,085 (was 10/623,729) in view of Shi (6,284,056) has been overcome. (This patent number is believed to be 6,284,050.) According to the examiner, there is "nothing in the claims, such as independent claim 1, required [sic] the 'Si-contained porous dielectric material' to be in a completely uncured state, nor need the plasma cure be or supply a fully [sic] cure, just some degree of curing, as presently claimed."

Claim 1 now recites "providing an uncured Si-containing porous dielectric material . . . exposing the uncured Si-containing porous dielectric material to a fluorine-free plasma gas; and plasma curing the uncured Si-containing porous dielectric material with the fluorine-free plasma gas to produce a plasma cured porous dielectric material." Support for these amendments can be found in paragraphs 0012-0014 and 0061. "However, by employing a fluorine-free plasma gas, the plasma cure process of the present invention defines a single-phase process that cures the film without causing unwanted changes therein. Accordingly, an additional post-cure treatment of the film need not be performed." Paragraph 0061.

The examiner stated that "(085)'s plasma treatment is an annealing step, hence implicated as effecting added curing." However, the '085 patent is directed to UV curing a porous dielectric material. UV curing yields a material with improved modulus and material hardness. The improvement is typically greater than or about 50%. The UV cured dielectric material can optionally be post-UV treated *to remove the polar species generated during the UV curing process*. Col. 8, lines 46-67. The post treatment reduces the dielectric constant of the material while maintaining that improved elastic modulus and material hardness as compared to the UV cured dielectric material. See Abstract, col. 7, lines 36-41, col. 8, lines 14-67.

Both the '085 patent and the present application cure porous dielectric materials, but they do so using different processes. The '085 patent UV cures the material, while the present application plasma cures with a fluorine-free plasma gas.

The formation of the initial porous dielectric material does not involve any initial curing steps. Porous dielectric materials typically require *a curing process after deposition*, as discussed in paragraphs 0012-0014. Various curing methods have been used including thermal curing, UV curing, and plasma curing. UV curing and plasma curing eliminate the need to thermally cure the porous dielectric material.

According to the examiner, "[0012] appears to discuss a 2 step curing process, unless the catalyst and H_2O step is in no way related to polymerization." Paragraph 0012 describes a method of making the uncured porous dielectric material, which is a starting material for the present invention. One of the steps in forming the porous coating involves exposing the coating to an environment including a catalyst and water. It is clear that this is a step in forming the porous coating because the next sentence describes evaporating the solvent from the coating *to form the porous network*. The paragraph indicates that the porous coating can optionally be cured. "*If desired*, the coating can be cured by heating to form a ceramic."

The examiner stated that "[0013] includes annealing steps as part of the curing process and appears to indicated [sic] that multistep procedures involving plasma as a second step are considered curing operations." However, paragraph 0013 describes thermal curing of the porous dielectric material. "Typical process conditions for curing these low-k films include nitrogen purged furnace anneals at temperatures between about 350 and about 450°C for 30 to 180 minutes." Thermal curing can generate unwanted polar species in some materials. These unwanted polar species can be removed with optional post-thermal cure treatments, including *plasma treatment* (not plasma cure).

Shi describes an ultraviolet-assisted chemical vapor deposition system. The processes include one or more depositions, one or more UV exposures, and one or more anneals. According to the examiner, "[g]iven teachings of Shi et al that treat like materials, and the present claims, where the "plasma curing" is after porous film or material formation, it would have been obvious to use UV treatment techniques as taught by Shi et al, followed by the present cases' "plasma curing", especially as Shi et al recommends post-treatments involving heat after UV curing." However, as discussed above, the *formation of the porous dielectric material does not require curing*. After the porous dielectric material is formed, it can be cured if desired using various processes. The present invention is directed to "providing an uncured Si-containing

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porous dielectric material . . . exposing the uncured Si-containing porous dielectric material to a fluorine-free plasma gas; and plasma curing the uncured Si-containing porous dielectric material with the fluorine-free plasma gas to produce a plasma cured porous dielectric material." Shi neither teaches nor suggests this process, alone or in combination with the '085 patent.

The rejection of claims 1-21 under 35 U.S.C. §103(a) as unpatentable over Catabay (U.S. 6,346,490), in view of Usami (U.S. 6,133,132) or Chung (U.S. 6,231,989) or Liu (U.S. 6,647,994) has been overcome. Catabay teaches treating the damaged surfaces of a low k carbon-containing silicon oxide material with one or more carbon-containing gases in the absence of an oxidizing agent. The treatment is designed to inhibit subsequent formation of silicon-hydroxyl bonds when the damaged surfaces of the low k dielectric material are thereafter exposed to moisture. The treatment is carried out after oxidizing or ashing the resist mask to remove the mask. The treatment can optionally be performed after the initial step of etching the low k carbon-containing silicon oxide dielectric material to form vias or openings.

The examiner correctly noted that there is no explicit statement in Catabay as to whether the low k dielectric is porous. However, the examiner stated that Catabay's "plasma treatment may be combined with N_2 densification, which would have been expected to be harder than the initial dielectric, and which implies that the initial untreated dielectric is relatively porous in order for densification to be induced, although no explicit teaching concerning porosity or lack thereof is found in Catabay et al." Contrary to the examiner's position, the N_2 densification process does not suggest a porous material. The N_2 densification process, cited at col. 5, line 59 to col. 6, line 14, is described in U.S. Patent No. 6,114,259. It involves forming a densified layer on and adjacent the exposed surfaces of a low k carbon doped silicon oxide dielectric material. The densified layer comprises silicon and nitrogen. The layer has a sufficient thickness to prevent degradation of the low k carbon doped silicon oxide dielectric material during the oxidizing step to remove the photoresist layer. An opening is etched in the low k carbon doped silicon oxide dielectric material, photoresist layer, and protective capping layer. The sidewalls of the opening are treated with a plasma to form the densified layer before the step of oxidizing or ashing the photoresist. U.S. Patent No. 6,114,259, Col. 3, line 64 to col. 4, line 39, and col. 4, line 63 to col. 5, lines 21.

Furthermore, the process cited in Catabay (col. 1, lines 50-60) for making low k carbon

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containing silicon oxide dielectric materials does not involve a porous material. U.S. Patent No. 6,303,047 describes a low dielectric constant multiple carbon-containing silicon oxide dielectric material. The material can be formed by reacting a mild oxidizing agent with a multiple carbon-substituted silane having only primary hydrogens bonded to the carbon atoms having a specified formula. In order to form a porous material, particular steps must be performed to create pores or voids, and the '047 patent does not teach any such steps. Neither the '047 patent nor Catabay ever mentions a porous dielectric material.

Therefore, Catabay does not teach or suggest the use of a porous dielectric material.

In addition, Catabay does not teach or suggest plasma curing a porous dielectric material, as claimed. Catabay states that the treatment can be carried out either with or without the use of plasma. First, if there is no plasma, there can be no plasma curing. Second, even when plasma is used in Catabay's treatment of damaged surfaces of low k carbon-containing silicon oxide dielectric materials, the process is not plasma curing, as claimed. In the present invention, plasma curing the porous dielectric material provides, among other things, chemical stability. The porous dielectric materials of the present invention are resistant to chemicals, such as cleaning solutions and chemical polishing solutions, as well as plasma damage during photoresist ashing and dry etching processes. See para. [0060].

Catabay's treatment takes place after the step of oxidizing or ashing the resist mask to remove the mask. It can also be carried out after the initial step of etching to form vias. Thus, Catabay's process is designed to treat damage that the present invention prevents from occurring in the first place. Catabay's material cannot be cured, even after the first treatment, because the damage occurs in both the etching and oxidizing steps.

According to the examiner, "[n]o comparison of before and after plasma treatment values, relative or specific, for the claimed dielectric constant, elastic modulus, or hardness is given, however the relationship as claimed is implied as noted above." However, as discussed above, Catabay does not teach or suggest using a porous dielectric material, nor does it teach or suggest plasma curing the porous dielectric material. Therefore, the claimed properties would not have been expected.

Usami, Chung, and Liu do not cure the deficiencies of Catabay. Usami teaches a thermally cured material. Col. 3, lines 7-21, and col. 4, lines 30-46. Chung also teaches

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thermally curing the material. Col. 7, line 45 to col. 8, line 17. Thermal curing is a different curing process from the claimed plasma curing. A proper combination of either Usami or Chung with Catabay, would result in the use of a thermally cured porous dielectric material which was then surface treated according to Catabay. This is not the claimed invention.

Liu does not discuss whether its material is cured or not. As Catabay does not teach or suggest plasma curing the porous dielectric material, the combination does not teach or suggest the claimed invention.

Therefore, claims 1-21 would not have been obvious to one of ordinary skill in the art at the time the invention was made over Catabay in view of Usami, Chung, or Liu.

Conclusion

Applicants respectfully submit that, in view of the above amendments and remarks, the application is in condition for allowance. The Examiner is encouraged to contact the undersigned to resolve efficiently any formal matters or to discuss any aspects of the application or of this response. Otherwise, early notification of allowable subject matter is respectfully solicited.

Respectfully submitted,
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